

CHARACTERISTICS OF COMPOST FROM BALINESE CATTLE DUNG (CD) AND RICE STRAW (RS) USING WHITE ROT FUNGUS (*Ganoderma sp*) AS BIOACTIVATORS

Muhammad Irfan Said^{*1)}, Jamila Mustabi²⁾, Siti Amelia Putri Syamsuddin³⁾

^{1,3)} Department of Animal Production, Faculty of Animal Science, Hasanuddin University, Tamalanrea Indah, Kec. Tamalanrea, Makassar City, South Sulawesi, Indonesia, 90245

²⁾ Department of Animal Feed and Nutrition, Faculty of Animal Science, Hasanuddin University, Tamalanrea Indah, Kec. Tamalanrea, Makassar City, South Sulawesi, Indonesia, 90245

E-mail: irfan.said@unhas.ac.id

Submitted 4 August 2020; Accepted 3 September 2020

ABSTRACT

To maximize the performance of the fermentation process, there is a need for a bioactivator. The purpose of this study was to evaluate the characteristics of compost-based waste from cattle dung (CD) combined with rice straw (RS) by applying white rot fungus (*Ganoderma sp*) as a bioactivator. In this study, 6 types of treatments have been applied, namely T₁(CD:RS)(25%:75%)+5% of Wrf; T₂(CD:RS)(50%:50%)+5% of Wrf; T₃(CD:RS)(75%:25%)+5% of Wrf; T₄ (CD:RS)(25%:25%)+0% of Wrf; T₅(CD:RS)(50%:50%)+0% of Wrf; T₆ (CD:RS)(75%:25%)+0% of Wrf. The study was designed experimentally using a completely randomized design (CRD), 6 treatments with 3 replications. Based on the research results, the difference in the ratio of CD to RS and the use of Wrf bioactivator has a significant effect ($p < 0.05$) in increasing the pH, temperature, C-organic and C/N ratio in compost. However, this difference had no significant effect ($p > 0.05$) on the C-organic value. The pH value of compost was obtained with variations of 5.50 ± 0.43 - 6.73 ± 0.06 . Temperature of compost is in the range of values 24.00 ± 0.00 - 25.67 ± 0.58 °C. The C-organic value is in the range of 24.38 ± 0.48 - 31.32 ± 0.80 %, while the N-organic value varies at 1.34 ± 0.11 - 2.10 ± 0.15 %. The C/N ratio is in the range of 15.00 ± 0.11 - 19.33 ± 1.15 . Based on the interaction, the results showed that there was a significant interaction ($p > 0.05$) between the use of Wrf bioactivator with the ratio of CD to RS on the parameters of pH, N-organic and C/Nratio, while, C-organic and temperature had no significant effect. The results of the study was concluded that several test parameters produced compost characteristics that were in accordance with Standar Nasional Indonesia (SNI) and the Regulation of the Minister of Agriculture of the Republic of Indonesia. Compost production using T₃ treatment ((CD:RS)(75%:25%) + 5% of Wrf) produces the best characteristics compared to other treatments.

Keywords: Compost; cattle dung; rice straw; white rot fungus; bioactivators

INTRODUCTION

Compost is one type of organic fertilizer as a result of breaking down living organisms (animals or plants) with the help of organisms (bioactivators). The need for compost has increased every year with the increasing need for food by humans. The compost production process is one of the efforts made to reduce waste production, especially solid waste (Neugebauer and Sołowiej, 2017; Pandey *et al.*, 2016; Proietti *et al.*, 2016). Compost fertilizer production is one solution to reduce the use of artificial fertilizers (chemical fertilizers). Compost can increase the availability of nutrients that have a positive impact on the soil and plants (Milinković *et al.*, 2019). The use of chemical fertilizers has been applied by the world community since the start of the green revolution movement (Leita *et al.*, 1999). The use of chemical fertilizers has a negative impact on the process of soil degradation and an increase in the process of soil pollution. This certainly has an impact on groundwater quality (Kaur *et al.*, 2008; Chaudhry *et al.*, 2009). In addition, the application of chemical fertilizers will have a very large impact on environmental sustainability (Akdeniz, 2019; Morari *et al.*, 2011).

The composting process is one of the technologies that has been widely applied in reducing solid waste, especially biomass. This process is one of the most important steps to support the supply of organic fertilizer for agricultural land needs (Neugebauer *et al.*, 2017; Pandey *et al.*, 2016; Proietti *et al.*, 2016). Mature compost will reduce the rate of heating, the thermophilic process, peak temperature and the rate of solid degradation. Adding mature compost may increase the cellulase,

peroxidase, arilsulfatase, and urease content during the mesophilic phase, and increase the urease content. During the cooling phase, it can however decrease cellulase, peroxidase, protease, and arilsulfatase (Ma *et al.*, 2019).

Utilization of waste from agriculture and livestock has been widely applied in the process of making compost. One type of livestock waste that can be developed as raw material for compost is cow dung (Said, 2014). To improve compost quality, bioactivators are needed as decomposing microorganisms. Balinese cattle is one of the many local cattle developed in Indonesia. In fact, the population of Balinese cattle dominates from the entire population of cattle in Indonesia. Balinese cattle population is estimated at 560,546 heads (Republika, 2020). Average dung production in beef cattle is in the range of 20 kg/head/ d (Saputro *et al.*, 2014). This amount is also likely to be owned by Balinese cattle. Based on these data, it can be projected that the amount of dung production will reach 11,210,920 kg or equivalent to 11,210.92 tons/d.

White rot fungus (Wrf) (*Ganoderma sp*) is one of the bioactivators that can be used as decomposers in the process of making compost. White rot fungus is one of the decomposing organisms that has able to degrade lignin and polysaccharide compounds well (Hsu and Buckley, 2008; Philippot *et al.*, 2011). White rot fungus (Wrf) was an organism of the fungus type that was able to degrade wood lignin compounds. The quality of compost were influenced by the ratio of the use of raw materials. To produce quality compost, the right material ratio and the role of bioactivators during the process are needed. This study aims to evaluate the

*Corresponding author:

Muhammad Irfan Said

Email: irfan.said@unhas.ac.id

Department of Animal Production, Faculty of Animal Science, Hasanuddin University, Tamalanrea Indah, Kec. Tamalanrea, Makassar City, South Sulawesi 90245 Indonesia

How to cite:

Said, M. I., Mustabi, J., & Syamsuddin, S. A. P. (2020). Characteristics of Compost from Balinese Cattle Dung (CD) and Rice Straw (RS) using White Rot Fungus (Wrf) (*Ganoderma sp*) As Bioactivators. *Jurnal Ilmu dan Teknologi Hasil Ternak*, 15 (3), 194-204

characteristics of compost using a combination of cow dung (CD) with rice straw (RS) at different ratios and the role of bioactivators.

MATERIALS AND METHODS

Materials

In this study, the main materials were waste from cattle dung (CD), rice straw (RS) and Wrf (*Ganoderma sp*) bioactivator. The CD were obtained from Balinese cattle at the Beef Cattle Laboratory, Faculty of Animal Science, Hasanuddin University, Makassar, Indonesia. The RS were obtained from fields in Makassar City, Indonesia. The Wrf bioactivators were obtained from the Waste and Biomass Valorization Laboratory, Faculty of Animal Science, Hasanuddin

University, Makassar, Indonesia. Some supporting equipment used were scale, pan, bucket, thermometer and pH meters.

Methods

Pretreatment

The raw material (CD and RS) were prepared 9 kg each. First of all, all the raw materials have been pasteurized using a steaming pan at 80°C for 15 min. Wrf (*Ganoderma sp*) bioactivators were prepared in the form of powder products.

Formulation material of compost

The pasteurized raw materials (CD and RS) were cooled at room temperature. The raw materials (CD and RS) were then ground to reduce particle size. The formula for compost and biactivator was then arranged as in Table 1.

Table 1. The composition of the materials used in making compost from each treatment

Materials	Treatments					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Cattle Dung (CD) (g)	250 (25%)	500 (50%)	750 (75%)	250 (25%)	500 (50%)	750 (75%)
Rice Straw (RS) (g)	750 (75%)	500 (50%)	250 (25%)	750 (75%)	500 (50%)	250 (25%)
Wrf (<i>Ganoderma sp</i>)	50	50	50	0	0	0
Bioactivator (g)	(5%)	(5%)	(5%)	(0%)	(0%)	(0%)

Fermentation process

The packaging used in making compost was a polybag clear plastic (HDPE) 15x20 cm size. The number of polybag prepared was 18 pieces. This amount is in accordance with the number of treatment units that have been applied (6 treatments and 3 replications). The raw materials (CD and RS) were put into polybag clear plastic, respectively according to the formula in Table 1. The fermentation process was carried out for 30 ds. The fermentation process was carried out semi-aerobically.

Methods of determining variables

- Temperature. Temperature was measured using a thermometer. The electrode part of the thermometer was put into compost and then the measurement results will be read.

- pH value (Agus, 2005). A total of 100g of compost sample was taken from 3 points in the compost heap. The pH meter was calibrated to validate the test results using a buffer of pH 7.0 and pH 4.0. The tip of the electrode was inserted into the sample and then the results were read.
- C-organic (Agus, 2005). Compost fertilizer samples (50g) were put into 100 ml volumetric flasks. Subsequent samples were added with K₂Cr₂O₇ 2 N (5 mL) and H₂SO₄ 98% (p.a) (7 mL). The mixture was homogenized by shaking. The mixture was allowed to stand for 30 min. A standard 250 ppm C solution was prepared. A standard solution of 5000 ppm (5 mL) was put into a volumetric flask (100 mL). The flask was added with a solution of H₂SO₄ + K₂Cr₂O₇ 2N solution each of 5 mL and

7 mL (as in the previous process). A standard solution (0 ppm C) was used as a standard solution. Each sample was diluted with aquadest. A total of 100 mL was then shaken until homogeneous and allowed to stand for 1 night. The results were measured by spectrophotometer at $\lambda = 651 \text{ nm}$. $\text{C-organic (\%)} = \text{ppm curve} \times 100 / \text{mg sample} \times \text{Fk}$, where ppm curve = standard regression curve; Fk = correction factor for water content = $100 / (100 - \% \text{ water content})$.

- **N-organic (Agus, 2005).** A total of 5 mg of compost sample was put into the Kjeldahl flask, added 0.25-0.50g selenium mixture + 3 mL H_2SO_4 (p.a). The solution was homogenized by shaking. The mixture was allowed to stand for 2-3 h. The solution was then processed for 3-3.5 h on a hotplate (150-350 °C). The process was carried out in stages until a clear solution was obtained. The solution was cooled and diluted. The solution was transferred to a volumetric flask (250 mL). In the volumetric flask, then adding aquadest to half the volume of the volumetric flask. The boiling stone was put into a volumetric flask. A total of 10 mL of 1% boric acid as a distillate reservoir was prepared in Erlenmeyer (100 mL). The solution was given with 3 drops of the Conway indicator. The distillation process was carried out by adding 20 mL of 40% NaOH solution. This process was completed when the volume of liquid in Erlenmeyer has reached 75 mL. The distillation results were titrated with H_2SO_4 0.05N, to the end point (the color of the solution changes from green to pink) = A mL, while the determination of blanks = A1 mL. The formula used, $\text{N-organic} = \text{total titration blank (mL)} - \text{titration sample} \times \text{N} \times \text{BST} \text{ N} / \text{sample weight (mg)} \times 100$, where BST N = nitrogen equivalent weight.
- **C/N ratio (Agus, 2005).** Determination of the value of the C/N ratio was done by comparing the value of C-organic with

N-organic. The formula was used, $\text{C/N ratio} = \text{C-organic value} / \text{N-organic value}$.

Research Design and Data Analysis

A completely randomized design (CRD) 6x3 Unidirectional Patterns has been applied in this research. The six treatments were applied T_1 (CD:RS)(25%: 75%) + 5% of Wrf; T_2 (CD:RS)(50%:50%) + 5% of Wrf; T_3 (CD:RS)(75%:25%) + 5% of Wrf; T_4 (CD:RS)(25%: 25%) + 0% of Wrf; T_5 (CD:RS)(50%:50%) + 0% of Wrf; T_6 (CD:RS)(75%:25%) + 0% of Wrf. Each treatment was repeated three times.

The research data were analyzed using ANOVA by the SPSS statistical program. Treatments that show a significant effect, then a significant difference test with Duncan's Multiple Range Test (DMRT) was performed at a level of 5% (Steel and Torrie, 1991).

RESULTS AND DISCUSSION

Temperature

Temperature is one of the important parameters for the fermentation process of organic matter. Temperature changes can be used as an indicator of the fermentation process. The different temperature values of each treatment were presented in Figure 1.

Based of ANOVA on the data (Figure 1), statistically, shows that the use of raw materials with different ratios (CD and RS) in the compost fermentation process has a very significant effect ($p < 0.01$) on changes in fermentation temperature. However, the application of different bioactivators and their interactions did not affect ($p > 0.05$) to the rate of temperature change during the fermentation process. The recorded temperature was the final temperature of the composting process. In general, the temperature was obtained in the range of $24.00 \pm 1.00 - 25.67 \pm 0.58$ °C.

The difference in the material ratio significantly increases the fermentation temperature. This is caused by the degradation ability of microorganisms that are different from each ingredient. An

increase in the ratio of CD usage has a positive correlation with an increase in fermentation temperature. This might be due to an increase in the amount of organic

matter so that bacterial activity also increases. Increasing the amount of organic matter will increase the rate of bacterial degradation.

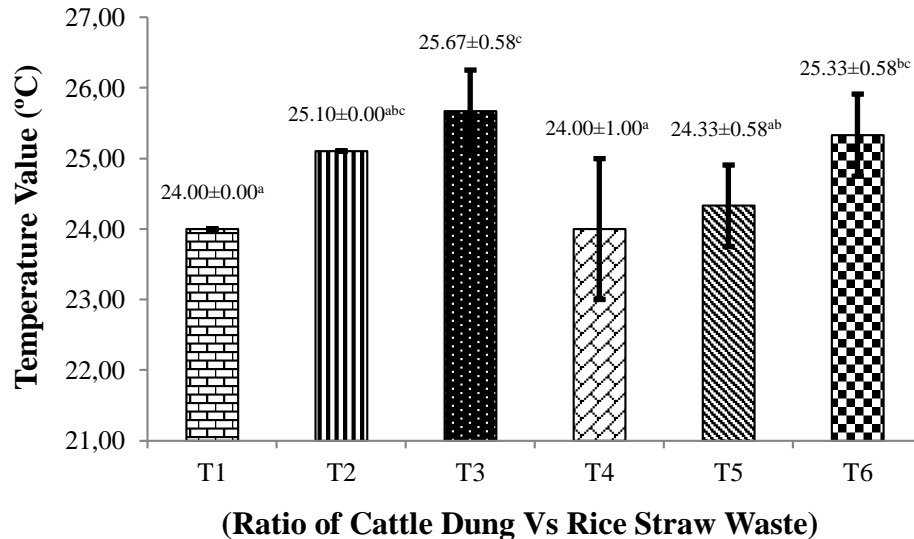


Figure 1. Comparison of temperature values of compost in various treatment ratios of materials and Wrf (*Ganoderma sp*) bioactivator application. T₁ (CD:RS)(25%:75%)+5% of Wrf; T₂ (CD:RS)(50%:50%)+5% of Wrf; T₃ (CD:RS)(75%:25%)+5% of Wrf; T₄ (CD:RS)(25%:25%)+0% of Wrf; T₅ (CD:RS)(50%:50%)+0% of Wrf; T₆ (CD:RS)(75%:25%)+0% of Wrf; ^{a,b,c} Different superscripts show significant differences ($p < 0.05$); Fermentation time = 30 ds; CD=Cow Dung; RS =Rice Straw; Wrf = White rot fungus (*Ganoderma sp*)

This will spur an increase in fermentation temperature (Zhu *et al.*, 2019). The composting process can reach temperatures of 60 °C. This temperature can activate pathogenic bacteria, viruses and worm eggs. The composting process is divided into 4 stages, namely: 1) mesophyll stage with a temperature of 30-40 °C, furthermore 2) the thermophile stage increased 50-70 °C, then 3) the cooking stage with temperatures 30-40 °C and 4) the cooling stage with temperatures <40 °C. The composting process that requires high temperatures is at the thermophile stage.

At this stage the population of mesophyll organisms decreases and the degradation of organic matter becomes high by the activity of thermophilic microorganisms. Environmental pH has increased (> 7) due to protein deamination to produce alkaline ammonia. At this stage

microorganisms (fungi) will secrete extracellular enzymes that will break down polymer compounds such as cellulose and complex carbohydrates. In this regard, the measured temperature of 25°C is the temperature data obtained in step (4), which is the cooling process. During the cooling process the compost temperature has dropped to <40°C.

The activity of mesophilic microorganisms is reactivated and the environmental pH gradually decreases. Nitrified bacteria that are inhibited at high temperatures will convert ammonia to nitrate so that the pH of the compost has decreased to near neutral pH (Said, 2014). The Wrf bioactivator was used to help the process of degradation of natural microorganisms that already exist in the material to degrade the components of organic material.

pH Value

The pH value plays an important role in the composting process. Acidic conditions in a media affect the activity of microorganisms (Zhang *et al.*, 2016). Changes in pH in compost were influenced by the production of organic acids carried out by microorganisms as bioactivators. The characteristics of compost pH at various different raw material ratios (CD and RS) were presented in Figure 1.

Based on the analysis of variance (ANOVA) (Figure 2) shows that the application of bioactivators in the process of making compost has a significant effect ($p < 0.05$) on the pH parameters. However, the difference in the ratio of CD and RS did not show any significant effect ($p > 0.05$). In general, it was seen that the pH value of each treatment varied considerably (5.50 ± 0.43 - 6.73 ± 0.04). This value is still in acidic to

neutral conditions. A low pH value (acid) can occur by the presence of Wrf (*Ganoderma sp*) microorganisms as bioactivators. Bioactivator activity is carried out through the fermentation process to produce acid. The pH value of compost by Mao *et al.* (2018) and Chen *et al.* (2017a) (2017b) is still higher than the pH value of the compost produced (7.5-7.8 and 8.1). This difference can be caused by the raw material and the type of bioactivator used. Where, the research conducted using biochar raw materials (corn stalks, bamboo, wood, manure, and coir). Increased oxygen consumption by microorganisms as bioactivators can cause high pH values. High pH values will provide a bad environment for activities other organics, however, a low pH value might be a cause of death in microorganisms (bioactivators) (Ratzke & Gore, 2018)

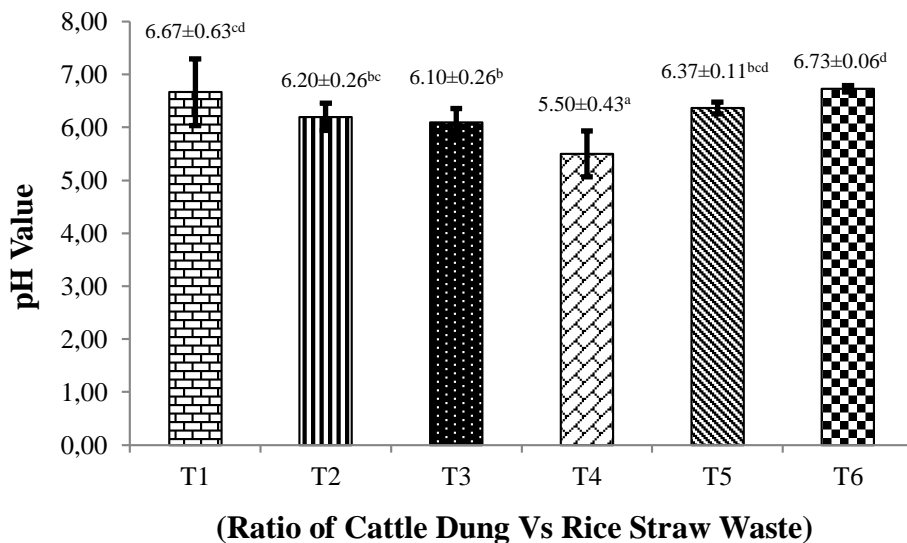


Figure 2. Comparison of pH values of compost in various treatment ratios of materials and Wrf (*Ganoderma sp*) bioactivator application. T₁ (CD:RS)(25%:75%)+5% of Wrf; T₂ (CD:RS)(50%:50%)+5% of Wrf; T₃ (CD:RS)(75%:25%)+5% of Wrf; T₄ (CD:RS)(25%: 25%)+0% of Wrf; T₅ (CD:RS)(50%:50%)+0% of Wrf; T₆ (CD:RS)(75%:25%)+0% of Wrf; ^{a,b,c,d} Different superscripts show significant differences ($p < 0.05$); Fermentation time = 30 ds; CD=Cow Dung; RS =Rice Straw; Wrf = White rot fungus (*Ganoderma sp*)

C-Organic

The availability of organic material in compost was related to the element carbon.

This element was needed by plants as a source of energy to carry out life and growth activities. White rot fungus (Wrf)

(*Ganoderma sp*) was a fungus type organism that was able to degrade lignin compounds from the wood. A description of the C-organic content of compost at various material ratios was presented in Figure 3.

The results of the ANOVA on the data in Figure 3 show that the application of Wrf bioactivators in the fermentation process had a very significant effect ($p < 0.01$) on the level of C-organic compost, however, differences in the ratio of materials (CD and RS) and their interactions did not show a significant effect ($p > 0.05$). These results indicate that the Wrf (*Ganoderma sp*) bioactivator has the ability to degrade and remodel compounds contained in raw materials into organic compounds that can

be utilized by plants. Based on Figure 3, it can be seen that the highest levels of C-organic ($31.32\% \pm 0.80$) were obtained from the ratio (CD: RS)(75%: 25%) by administering Wrf bioactivators (T_3 treatment). This ratio shows that the comparison of raw materials is very important and determines the final quality of compost.

The raw material (CD) was rich in nitrogen compounds (N), whereas, RS was rich in carbon compounds (C). Bioactivators play a role in overhauling compost raw materials by producing certain enzymes. This has a direct effect on the availability of carbon in compost (Wang *et al.*, 2019; Wu *et al.*, 2017).

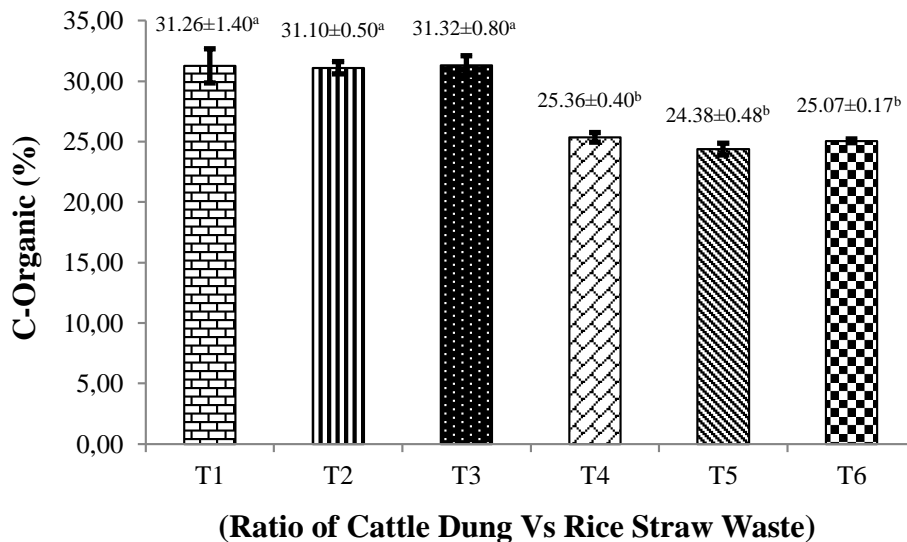


Figure 3. Comparison of C-organic of compost in various treatment ratios of materials and Wrf (*Ganoderma sp*) bioactivator application. T_1 (CD:RS)(25%:75%)+5% of Wrf; T_2 (CD:RS)(50%:50%)+5% of Wrf; T_3 (CD:RS)(75%:25%)+5% of Wrf; T_4 (CD:RS)(25%: 25%)+0% of Wrf; T_5 (CD:RS)(50%:50%)+0% of Wrf; T_6 (CD:RS)(75%:25%)+0% of Wrf; Fermentation time = 30 ds; CD=Cow Dung; RS =Rice Straw; Wrf = White rot fungus (*Ganoderma sp*)

N-Organic

N-organic parameters are important in assessing the quality of compost. The availability of nitrogen (N) in compost determines the quality of compost. The element nitrogen is the main ingredient needed by microorganisms to synthesize proteins. The characteristics of compost N-organic from several different material

ratios (CD and RS) were presented in Figure 4. The results of the ANOVA on the data in Figure 4 show that the use of bioactivators and the difference in the ratio of material use (CD and RS) have a very significant effect ($p < 0.01$) on the N-organic value of compost. However, there was no significant interaction ($p > 0.05$) between the use of bioactivators with the ratio of material use.

The data in Figure 4 shows that the N-organic value of the compost fermented using Wrf (*Ganoderma sp*) bioactivators (T₁, T₂ and T₃) was on average higher than without Wrf (T₄, T₅ and T₆). The results of the study generally showed that the T₃ treatment produced the highest N-organic value ($2.10\% \pm 0.15$), while the lowest value at the T₄ treatment ($1.34\% \pm 0.11$). Based on the data, it is also seen that there is a tendency to increase the value of N-organic with the increasing proportion of CD use compared to the proportion of RS. This is caused by the activity of microorganisms that cause an increase in degradation.

Changes in the cycle of microorganisms largely determine the dynamics of mineralization and nutrition (Sileshi *et al.*, 2017). In addition, the degradation process in the composting process causes the formation of N-organic bioavailability (Zhu *et al.*, 2019). The application of WRF bio-activators increases the proportion of N-organic in compost. N-organic donations are mostly obtained from the high proportion of CD in the mixture. This increase in N-organic will increase and improve the quality of compost as a provider of N compounds for bacteria to form proteins.

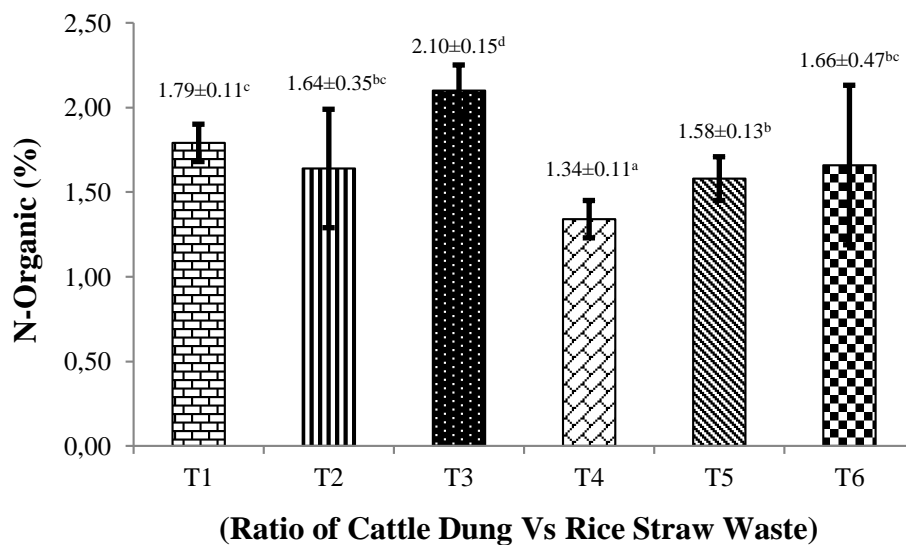


Figure 4. Comparison of N-organic of compost in various treatment ratios of materials and Wrf (*Ganoderma sp*) bioactivator application. T₁ (CD:RS)(25%:75%)+5% of Wrf; T₂ (CD:RS)(50%:50%)+5% of Wrf; T₃ (CD:RS)(75%:25%)+5% of Wrf; T₄ (CD:RS)(25%: 25%)+0% of Wrf; T₅ (CD:RS)(50%:50%)+0% of Wrf; T₆ (CD:RS)(75%:25%)+0% of Wrf; Fermentation time = 30 ds; CD=Cow Dung; RS =Rice Straw; Wrf = White rot fungus (*Ganoderma sp*)

C/N ratio

C/N ratio value shows the comparison between C and N content in a media. The element carbon (C) is used by microorganisms as an energy source to produce the element nitrogen (N). The C/N ratio value of compost made from different raw material ratios (CD and RS) were presented in Figure 5.

Statistically, using ANOVA, data in Figure 5 shows that the difference in the

ratio of material use and interactions has a very significant effect ($p < 0.01$) on changes in the C/N ratio of compost. However, the difference in the use of Wrf bioactivators did not show any significance ($p > 0.05$). The availability of organic material in compost has a very important role. The carbon element in organic matter is utilized by microorganisms in bioactivators as an energy source. In general, the C/N ratio obtained is in the range of 15.00 ± 1.73 -

19.33±1.15. Based on the standard requirements for compost C/N ratio according to SNI 19-7030-2004 is 10-20.

This shows that the C/N ratio of compost produced is still in accordance with these requirements.

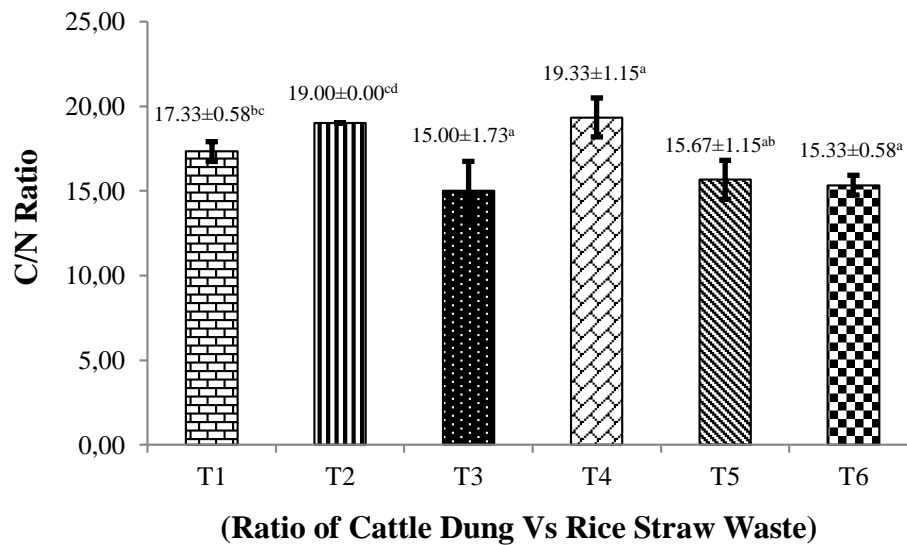


Figure 5. Comparison of C/N ratio of compost in various treatment ratios of materials and Wrf (*Ganoderma sp*) bioactivator application. T₁ (CD:RS)(25%:75%)+5% of Wrf; T₂ (CD:RS)(50%:50%)+5% of Wrf; T₃ (CD:RS)(75%:25%)+5% of Wrf; T₄ (CD:RS)(25%: 25%)+0% of Wrf; T₅ (CD:RS)(50%:50%)+0% of Wrf; T₆ (CD:RS)(75%:25%)+0% of Wrf; ^{a,b,c,d} Different superscripts show significant differences (p<0.05); Fermentation time = 30 ds; CD=Cow Dung; RS =Rice Straw; Wrf = White rot fungus (*Ganoderma sp*)

According to Wang *et al.*, (2019), compost with a C/N ratio of 22 shows the most effective immobilization. The value of C/N ratio of 15-27 does not have a big influence on the quality of compost. The composting process is an attempt to reduce the value of the C/N ratio of an organic material. The expected value is close to C/N ratio of soil (<20). The availability of N-organic by microorganism activity was influenced by the C/N ratio and pH (Zhu *et al.*, 2019).

CONCLUSION

The application of Wrf (*Ganoderma sp*) bioactivators in the fermentation process of raw materials (CD and RS) significantly increases the value of C-organic and N-organic of compost, but does not show an effect on temperature, pH and C/N ratio. The difference in the ratio of material use

significantly increases the temperature, N-organic as well as the C/N ratio in compost. There is a positive interaction between the use of Wrf bioactivators with the ratio of material use (CD and RS) to pH, N-organic and C/N ratio of compost. The use of (CD:RS) ratio (75%:25%) fermented using Wrf bioactivators (T₃ treatment) produces the best compost characteristics compared to other treatments.

Conflict of Interest

There are no conflict of interest between researchers and the organizations or institutions that collaborate and are involved in this research.

ACKNOWLEDGMENTS

The research team would like to thank the Rector of Hasanuddin University and the Dean of the Faculty of Animal Science, Hasanuddin University, for the facilities

provided. The research team specifically thanks to the student research team for their participation and cooperation in conducting the research.

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